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Nuclear Fuels and Related Materials

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Present and future nuclear fuel cycles will require an understanding of the complex chemistry of trace fission products and transuranium actinides in used nuclear fuel and related nuclear materials. Because of the unique analytical challenges that used nuclear fuel presents to the materials scientist, many of its fundamental physical and chemical properties remain poorly understood, especially on the microscopic scale. For example, important radionuclides, such as technetium and neptunium, are present in used nuclear fuel at concentrations much less than 1%, and the fuel matrix (e.g., uranium oxide), with its own complex spectroscopy, creates a formidable technical hurdle to understanding trace element microstructure. An understanding of the chemical states of radionuclides in used nuclear fuel would benefit development of technologies for fuel monitoring, fuel performance improvement and modeling, fuel reprocessing, and storage and disposal of used fuel. We have demonstrated the use of synchrotron X-ray absorption spectroscopy (XAS) to examine crystal chemical properties of actinides and fission products in specimens of used uranium oxide fuel and other radionuclide-bearing materials from the nuclear fuel cycle. Information obtained includes oxidation state, chemical bond coordination, and quantitative elemental concentration and distribution. We have also used XAS in a scanning mode to obtain X-ray spectral micrographs with resolution approaching 1 micron. A brief overview of technique will be presented, along with findings on uranium, plutonium, neptunium, technetium, and molybdenum in commercial used nuclear fuel specimens.

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